

**Remarks/Arguments**

The above Amendments and these Remarks are in reply to the Office Action mailed July 17, 2003.

Claims 1-23, 25, 29, 30, 48-50 were pending in the Application prior to the outstanding Office Action. In the Office Action, the Examiner rejected claims 1-23, 25, 29, 30, 48-50. The present Response amends claims 1, 3, 22, 25, 48, 49, and 50. Applicants respectfully reinstate all previous remarks herein by reference.

Claims 1, 20, and 21 were rejected under 35 USC 102(e) as being anticipated by Kwon et al. (US 6,333,260; hereafter Kwon). Applicants respectfully submit that the amended claim 1, a "single diffusion barrier," is distinguished over Kwon. Kwon specifically recites at least two separate layers: structure 350 "may be either a single layer or a multilayered combination" (column 5, lines 58-59), and additionally Kwon discloses a layer 360. The Action states that there is a layer of doped dielectric deposited on layer 350. Applicants respectfully disagree, since Kwon discloses structure 350 in combination with structure 360, described in column 6, lines 20-23 (underline added for emphasis) as,

For example, the interface protection layer 360 may be made from aluminum oxide ( $\text{Al}_2\text{O}_3$ ), silicon nitride ( $\text{SiN}$ ), or silicon oxynitride ( $\text{SiON}$ ) in a layer that covers the metal film pattern 310.

Layer 360 is not a metal nitride, since silicon is a metalloid, and not a metal. Since layer 350 does not completely cover all surfaces of the metal layer (e.g., see Kwon, Figure 3), absent layer 360, the metal layer 310 of Kwon would have metal surfaces in contact with a doped dielectric layer. In either layer 350, or layer 360, or in combination thereof, Kwon does not disclose a single layer of a metal nitride on a metal layer, which prevents direct contact of a doped dielectric layer from a metal layer, thus acting as a diffusion barrier for dopants diffusing into the metal layer. Since Kwon discloses a layer of titanium or titanium nitride not completely covering all surfaces of a metal layer in combination with an interface protection layer that is not comprised of a metal nitride layer, there is nothing, either express or inherent, in Kwon that anticipates a single metal nitride layer acting as a diffusion barrier. Since claims 20 and 21 depend from amended claim 1, it is further submitted that they are patentable for at least the reason given for the parent claim.

Claim 19, which recites the temperature range for the step of depositing a layer of doped dielectric, is rejected under 35 USC 103(a) as unpatentable over Kwon. Applicants respectfully submit that Kwon teaches a combination of a layer of titanium nitride or titanium with a layer of aluminum oxide, silicon nitride, or silicon oxynitride, which are between a metal layer and a doped dielectric layer. Kwon teaches away from depositing a single layer of a metal nitride on a metal layer, so as to prevent direct contact of a doped dielectric layer with a metal layer. Further there is no motivation provided by Kwon for a single nitride layer on a metal layer to prevent contact of the dielectric layer from the metal layer. Removal of layer 360 of Kwon results in layer 350, which by itself allows contact of the metal layer with the doped dielectric layer. Removal of layer 350 of Kwon results in an interface protection layer 360, which is not a metal nitride layer. Therefore, Kwon does not render claim 1 obvious. Since claim 19 depends on claim 1, Kwon does therefore not render claim 19 obvious under 35 USC 103(a) for at least the same reason.

Claims 1, 3-13, 16-18, 20-23, and 25 stand rejected under 35 USC 103(a) as being unpatentable over Liu et al. (US 6080657; hereafter Liu) in view of Lu et al. (US 6365517; hereafter Lu). Specific attention is directed to Liu, figure 6, wherein a metal line created after processing of the metal layer in figure 5 is shown in direct contact with insulating layer 18. Insulating layer 18 is described as composed of silicon dioxide, tetraethoxysilane oxide, borophosphosilicate glass, or the like (column 2, lines 51-55). The structure shown in figure 6, therefore, shows a metal surface in direct contact with a doped dielectric layer.

Independent claims 1, 3, 22, and 25 have been amended to reflect what is consistent in the subject specification regarding the deposition of a single layer of a metal nitride on a metal surface in a semiconductor device to prevent the metal surface from direct contact with a doped dielectric layer (i.e. paragraphs 75,76; figs. 2b, 4).

Lu teaches the chemical deposition of  $TiN$ ,  $TiSi_xN_y$ , and  $TiN_xB_y$  over insulating layers to protect the insulating layers from metal contamination in a subsequent step of deposition of metal onto an insulating layer (column 4, lines 36-43). There is nothing in Lu that teaches the deposition of a "single diffusion barrier" on a metal layer, where the diffusion barrier "prevents direct contact of said doped dielectric with said metal layer." The chemical deposition of  $TiN$ ,  $TiSi_xN_y$ , and  $TiN_xB_y$  on a dielectric layer is a different structure than that which is taught in the subject application, and addresses a completely different problem.

Liu clearly shows a device prepared by a method that resulted in a metal surface directly in contact with a doped dielectric layer, in contrast to the instant claims as amended. Liu teaches away from "a single diffusion barrier" as in claims 1, 3 and 22, or "a single layer of metal nitride" as in claim 25, which "prevents contact of said metal layer with said doped dielectric layer." Since Liu teaches away from the instant disclosure, and since Lu teaches a different structure from that of the instant disclosure, there is no motivation to combine Liu and Lu, and even if there were a motive to combine the references, the combination would not provide a reasonable expectation of success at arriving at the Applicants' claimed invention. Thus, the combination of Liu and Lu together would not render obvious that which is claimed in the subject application. Applicants further submit, that claims 4-13, 16-18, and 20-23 that depend from claims 1 and 22 are patentable for at least the reasons given for the patentability of claims 1 and 22.

Additionally, Applicants request that the rejection of dependent claims 14 and 15 under 35 USC 103(a) be withdrawn for essentially the same argument presented for claims 3-13, 16-18, and 20-23. Since amended claim 1 is a structure neither taught nor suggested by the combination of Liu in view of Lu, and since Inoue does not further teach or suggest the structure made by the method of claim 1, then claim 1 is patentable over Liu in view of Lu in further view of Inoue. Claims 14 and 15 depending on claim 1 are therefore patentable for at least the same reason.

Claims 29 and 30 are rejected under 35 USC 103(a) over Kwon in view of Applicants' "admitted prior art." As previously stated, Kwon teaches away from a metal layer with a single layer of a metal nitride as a diffusion barrier, which prevents direct contact of the metal layer with a doped dielectric layer. Further, Applicants' paragraph 78 states, "The nitride can be manufactured in any convenient fashion." The mere existence in the art of a nitride layer does not teach or suggest the use of such a layer to prevent the problem of the contamination of metal layers by dopants from doped dielectric layers. There is no motivation to combine Kwon and the art broadly referred to in paragraph 78 of the subject application.

Claims 48-50 are rejected under 35 USC 103(a) over Geffken et al. (US 5,985,762; hereafter Geffken) in view of Akram (US 5,661,334; hereafter Akram). The Action states that Geffken discloses, "...a method of reducing diffusion of dopant ions from a doped dielectric layer into a metal layer 3 or 21 of a device stack having a metal layer, comprising the steps of: forming a trench in said device stack, said

trench having at least one sidewall; depositing on at least one sidewall a metal layer, a diffusion barrier 28 or 29, said diffusion barrier comprised of a layer of tantalum nitride or titanium nitride..."

Applicants respectfully disagree with the characterization of Geffken as stated in the Action because Geffken teaches away from Applicants' claims. The problem addressed in Geffken relates to copper diffusion into an insulating layer, and not to the diffusion of dopant ions, such as fluoride ions, from doped dielectric layers into metal layers in a device stack. Specifically, barrier layer 5 in figure, or barrier layer 28 in figures 3C-3E are described as either metallic or insulating, since for the purpose of creating a barrier for copper ions diffusing into a dielectric layer, selections from either class will suffice, since, as per column 2 lines 43-48, the purpose of the barrier layer is given as:

The chief requirement of the barrier layer is that it prevent copper and copper oxide from coming into contact with the oxide or "ILD" during directional etch and allowing the via to be filled with copper after etching without copper coming into contact with the ILD.

Further, layer 29 is described as an adhesion and diffusion barrier layer. Since copper requires an adhesion layer, the laying down of such a layer before filling the vias and wires with copper is necessary. Regarding the function and composition of layer 29 as a diffusion layer, the composition for layer 29 is the same as that described previously for layer 5 or layer 28. Further, figures 3C-3E teach a multilayered adhesion/barrier layer (column 3, lines 39-43) for layers 28 and 29:

The adhesion layer can be the same or different from the barrier layer. In some applications, it may be advantageous to have the barrier/adhesion layer 29 be a conducting material and the barrier layer 28 be an insulating material.

Geffken teaches the use of **multiple material layers** in the fabrication of interconnect structures comprised of copper wires and vias so as to preclude copper contamination of a dielectric layer during fabrication, and to provide an adhesion layer for the copper structures. Geffken teaches away from preparing the sidewalls of a trench in a device stack with "a **single diffusion barrier**," which "prevents the direct contact of said metal layer with said doped dielectric layer" of Applicants' claims.

Akram teaches away from Applicants' claims. Akram teaches the fabrication of layers of metal line patterns in devices having inter-metal dielectric structures with low dielectric constant for reducing parasitic capacitance in such devices. Akram does not teach depositing a single metal nitride layer on the sidewalls of a trench in a device stack, but rather teaches deposition of a barrier film layer on an interlevel dielectric layer (column 3, lines 27-35), or on top of metal line patterns interspersed with a barrier layer

(column 5, lines 32-35; figure 5). The structures taught by Akram are not the sidewalls of a trench of a device stack of the subject application. Geffken in combination with Akram would not teach the what is claimed in the subject application, and there is no motivation to combine Geffken with Akram. Even if there were a motive to combine Geffken and Akram, the combination would not produce Applicants' claims with a reasonable likelihood of success, and thus, the combination of Geffken and Akram cannot render Applicants' claims obvious.

Conclusion

In light of the above amendments, and arguments set forth, it is respectfully submitted that all of the claims now pending in the subject patent application should be allowable, and a Notice of Allowance is requested. The Examiner is respectfully requested to telephone the undersigned if she can assist in any way in expediting issuance of a patent.

Respectfully submitted,

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